

## CLAIMS

1. A force feedback interface device coupled to a host computer system implementing a host application program, the interface device comprising:

5 a user manipulatable object physically contacted by a user and movable in physical space in at least one degree of freedom with respect to a ground, said movement being approximately within a single plane;

10 a sensor operative to detect said movement of said user manipulatable object in physical space in said at least one degree of freedom with respect to said ground and to output sensor signals representative of said movement; and

15 an actuator coupled to said user manipulatable object and operative to apply a linear output force in a direction approximately perpendicular to said single plane of movement, said force applied along an axis extending through said user manipulatable object to an entire portion of said user manipulatable object grasped or rested upon by a hand of said user.

20 2. A force feedback interface device as recited in claim 1 wherein said user manipulatable object is a mouse moveable in two degrees of freedom within said single plane.

25 3. A force feedback interface device as recited in claim 2 wherein said entire grasped portion of said mouse moves as a result of receiving said force, wherein said movement is not sensed by said force feedback interface device.

4. A force feedback interface device as recited in claim 2 wherein said actuator is coupled to a housing of said mouse and moves a portion of said housing in said direction approximately perpendicular to said plane.

5. A force feedback interface device as recited in claim 4 wherein a cover portion of said housing is movably coupled to a base portion of said housing, and wherein said cover portion is moved by said actuator with respect to said base portion.

6. A force feedback interface device as recited in claim 5 wherein said cover portion is coupled to said base portion by a hinge.

30 7. A force feedback interface device as recited in claim 1 wherein said actuator is a linear actuator.

8. A force feedback interface device as recited in claim 7 wherein said linear actuator is a voice coil actuator.

9. A force feedback interface device as recited in claim 5 wherein said sensor includes two sensors, each of said sensors detecting movement of said mouse in one of said degrees of freedom in said single plane.

10. A force feedback interface device as recited in claim 4 wherein said output force is correlated with a graphical representation displayed by said host computer, wherein a position of said mouse in said plane corresponds with a position of a cursor displayed in said graphical representation.

11. A force feedback interface device as recited in claim 10 wherein said output force is a jolt correlated with the interaction of a user-controlled cursor with a graphical object displayed in a graphical user interface.

12. A force feedback interface device as recited in claim 11 wherein said jolt is output with a magnitude dependent on a characteristic of said graphical object with which said cursor interacts.

13. A force feedback interface device as recited in claim 12 wherein said characteristic of said graphical object is a type of said graphical object, wherein said type includes one of an icon, a window, and a menu item.

14. A force feedback interface device as recited in claim 10 wherein said graphical representation includes a representation of a 3-D area having different elevations, and wherein said output force is correlated with an elevation of a portion of said graphical representation on which said cursor is displayed.

15. A force feedback interface device as recited in claim 1 wherein said user manipulatable object is a stylus.

16. A force feedback interface device as recited in claim 15 wherein said linear output force is output along a lengthwise axis extending through said stylus.

17. A force feedback interface device as recited in claim 1 wherein said force is included in a force sensation, said force sensation being one of a jolt, vibration, constant force, and texture force.

18. A force feedback interface device as recited in claim 1 wherein said actuator outputs said force directly on said user manipulatable object, wherein no transmission system is provided between said actuator and said user manipulatable object.

5 19. A force feedback interface device as recited in claim 1 wherein said user manipulatable object is a wheel rotatable in said single plane, wherein said axis extends approximately through a center of said wheel.

20. A force feedback interface device coupled to a host computer system implementing a host application program, the interface device comprising:

10 a user manipulatable object physically contacted by a user and movable in physical space in two rotary degrees of freedom with respect to a ground, said degrees of freedom approximately defining at least a portion of a surface of a sphere;

15 at least one sensor operative to detect said movement of said user manipulatable object in physical space in said two degrees of freedom with respect to said ground and output sensor signals representative of said movement; and

20 an actuator coupled to said user manipulatable object and operative to apply an output force in a linear degree of freedom that is approximately radial to said sphere and not in said two degrees of freedom, wherein said force is applied along a lengthwise axis of said user manipulatable object, and wherein said force feedback interface device includes no other actuators.

21. A force feedback interface device as recited in claim 20 wherein said user manipulatable object is at least a portion of a joystick handle.

22. A force feedback interface device as recited in claim 21 wherein said actuator is a linear actuator.

25 23. A force feedback interface device as recited in claim 22 wherein said actuator is a linear voice coil actuator.

24. A force feedback interface device as recited in claim 20 wherein motion along said lengthwise axis is not sensed by said force feedback interface device.

25. A force feedback interface device as recited in claim 21 wherein said actuator includes a mechanical spring for biasing said at least a portion of said joystick handle toward an extended position.

26. A force feedback interface device as recited in claim 21 wherein said actuator includes a plurality of magnets for biasing said at least a portion of said joystick handle toward an extended position.

27. A force feedback interface device as recited in claim 20 wherein said actuator outputs said force directly on said user manipulatable object, wherein no transmission system is provided between said actuator and said user manipulatable object.

28. A force feedback interface device as recited in claim 20 further comprising a microprocessor, separate from said host computer, coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator for controlling said output force on said user object, and operative to receive said sensor signals from said sensors and report locative data to said host computer derived from said sensor signals and indicative of said movement of said user manipulatable object.

29. A force feedback interface device coupled to a host computer system implementing a host application program, the interface device comprising:

a user manipulatable object physically contacted by a user and movable in physical space in a plurality of degrees of freedom with respect to a ground;

at least one sensor operative to detect said movement of said user manipulatable object in physical space in said plurality of degrees of freedom with respect to said ground and output sensor signals representative of said movement;

a linear actuator coupled to said user manipulatable object and operative to apply a linear output force only along a lengthwise axis of said user manipulatable object and not in said plurality of degrees of freedom, wherein said force feedback device includes no other actuators.

30. A force feedback interface device as recited in claim 29 wherein said user manipulatable object is a stylus and said sensor is included in a tablet that can be contacted by said stylus.

31. A force feedback interface device as recited in claim 30 wherein said stylus is not coupled to a mechanical linkage and is free to be moved by said user.

32. A force feedback interface device as recited in claim 30 wherein said stylus includes a rigid tip for contact with said tablet, and wherein said actuator outputs a force to move a body portion of said stylus relative to a tip portion of said stylus.

33. A force feedback interface device as recited in claim 30 wherein said stylus includes a ball in a tip of said stylus, said ball rotating in place when said stylus is moved across a surface.

34. A force feedback interface device as recited in claim 33 wherein said actuator moves a brake pad against said ball to output a resistive force on said stylus.

35. A force feedback interface device as recited in claim 29 wherein motion along said lengthwise axis is not sensed by said force feedback interface device.

36. A force feedback interface device as recited in claim 29 wherein said user manipulatable object is a joystick handle and said plurality of degrees of freedom are rotary degrees of freedom, wherein a grip portion of said joystick handle is linearly moved along said lengthwise axis by said actuator relative to a base portion of said joystick handle.

37. A force feedback interface device as recited in claim 36 wherein said actuator includes a physical spring for biasing said at least a portion of said joystick handle toward an extended position.

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